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TECHNICAL REPORT NO. 8-66

PERFORMANCE EVALUATION
35-FOOT DIAMETER EXTENDED SKIRT
MANEUVERABLE PERSONNEL PARACHUTE
CANOPY ASSEMBLY WITH "TU" ORIFICE

Final Report
April 1967

by

George L. C. Menard

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TECHNICAL REPORT NO. 8-66

U. S. NAVAL AEROSPACE RECOVERY FACILITY

Capt. C. W. Roesner, USNR — Commanding Officer

Howard C. Fish — Technical Director

PERFORMANCE EVALUATION
35-FOOT DIAMETER EXTENDED SKIRT
MANEUVERABLE PERSONNEL PARACHUTE
CANOPY ASSEMBLY WITH "TU" ORIFICE

by

George L. C. Menard

El Centro, California
April 1967

ABSTRACT

This report covers the development, test, and evaluation of a maneuverable personnel parachute canopy assembly modification. The canopy assembly tested was constructed from the basic 35-foot diameter extended skirt canopy assembly, AF 49J7141-2, used with Personnel Parachute, Troop-Back, 35-Foot Diameter, Type T-10, A/P28S-14. A "TU" type of orifice was installed in the canopy, and the slip risers utilized with the maneuverable personnel parachute assemblies, A/P28S-10 (Static Line) and A/P28S-13 (Free Fall) for steering the parachute, were replaced by standard risers, AF 59C6174, and control lines.

A total of 193 torso dummy tests in the weight categories of 250 and 300 pounds were conducted to obtain data on the rate of descent, horizontal speed, opening forces, and parachute performance at low and high altitudes. The dummies were launched at airspeeds varying from 80 to 225 KIAS and at altitudes ranging from 1,000 to 15,000 feet.

A live jump test program was conducted in the weight categories of 200, 250, 300 pounds to determine the rate of descent, turn rate, horizontal speed, oscillation, minimum safe deployment altitude, and parachute performance and reliability. A total of 401 tests were completed. Tests were made at exit airspeeds of 80 to 130 KIAS for static line jumps, and 80 to 200 KIAS for free fall jumps at altitudes of 5,000 to 10,000 feet.

The results of this test and evaluation program indicate that the canopy assembly modification provides more maneuverability and a better turn rate performance than that currently obtainable with the maneuverable personnel parachute assemblies, Types A/P28S-10 and A/P28S-13.

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INTRODUCTION

Background. The Naval Aerospace Recovery Facility (NAVAERO-RECOVFAC) received a request from Headquarters, Naval Air Systems Command, Washington, D. C., to establish a program for the test and evaluation of a design for a maneuverable personnel parachute canopy assembly and a deployment bag, which had been recommended by the Commander, Naval Operations Support Group, Atlantic (COMNAVOP-SUPPGRULANT). This proposed design incorporated a "TU" type of orifice in the rear of the 35-foot diameter extended skirt canopy utilized in the A/P28S-14, Static Line, Personnel, Troop-Back, Parachute Assembly, Type T-10. Control lines were attached to the suspension lines numbered 7 and 24 at a point 10 feet above the connector links and to the toggles located on the front of the rear risers for steering the maneuverable parachute, in lieu of the slip risers normally employed. The objective of the proposed canopy modification was to provide better performance characteristics, than those described below for the current approved military maneuverable personnel canopy assemblies used with Types A/P28S-10 (Static Line) and A/P28S-13 (Free Fall) parachute assemblies, by:

a. Simplifying the steering of the parachute with the installation of control lines.

b. Providing a faster turn rate.

c. Increasing the forward speed.

d. Improving the overall maneuverability.

The current military types of maneuverable personnel parachute assemblies, A/P28S-10 and A/P28S-13 respectively, use a basic 35-foot diameter extended skirt canopy, which has been modified by locating a polygon-shaped orifice symmetrically on the fore and aft centerline in the rear of the canopy. The orifice allows air in the inflated canopy to escape, propelling the canopy in a forward motion at approximately 6 feet/second. The suspension line reinforcement in the radial seams is left intact to provide structural and shape integrity. Canopy deformation and resultant directional change is obtained through the use of slip risers. Slip risers are similar to conventional risers, except that the midpoint is not restricted, and shortening of the front or rear riser results in an equal lengthening of the opposite portion of the riser and distorts the orifice and canopy shape causing the canopy to rotate. Right or left hand 180-degree turns can be executed in

approximately 9 seconds. A shortened right rear or a left front riser will result in a turn to the right, and a shortened left rear or a right front riser will result in a rotation to the left. Shortening both front risers an equal amount will increase the forward speed; shortening both rear risers will decrease the forward speed. Either procedure will result in an increased rate of descent.

The continual effort required to steer the parachute during descent with slip risers can be fatiguing, and can result in a fully equipped military parachutist not being at top efficiency immediately upon landing. Also, there is the inherent problem of the parachutist endeavoring to remember which riser he must shorten in order to make a turn to the right or left.

The use of control lines instead of slip risers enables the parachutist to maneuver more easily. For example, by having the control lines attached directly to the canopy, the parachutist by merely pulling down on the right control line immediately distorts the orifice, causing the canopy to turn to the right; pulling down on the left control line results in the canopy rotating to the left. The speed at which the canopy rotates is affected by the weight of the parachutist and the distance each control line is pulled down. Pulling both control lines simultaneously will reduce the forward speed. This action is known as "braking".

Upon receipt of the prototypes of the proposed canopy assembly and deployment bag from COMNAVOPSUPPGRULANT, an inspection and analysis was made of each item. The findings indicated that there were some dimensional and constructional problems which would have to be resolved before proceeding with the test program.

A conference was held, therefore, on 19 August 1965 at NAVAERO-RECOVFAC, El Centro, California, with representatives of COMNAV-OPSUPPGRULANT and COMNAVOPSUPPGRUPAC. The purpose of this meeting was to discuss, clarify, and resolve the final details for the modification of the canopy assembly, and the parameters for the test and evaluation program. Since the proposed modification could not be satisfactorily accomplished on the canopy assemblies used with the A/P28S-10 and A/P28S-13 parachute assemblies without making a major alteration to the orifice, this Facility presented a revision to the modification for consideration. See FIG. 1 and FIG. 2. The modification, as revised, can be readily accomplished on either the canopy in the A/P28S-14 assembly, or on the canopies in the A/P28S-10 and A/P28S-13 assemblies by utilizing the present orifice. Also, this

revision relocated the attachment of the control lines from the suspension lines to the bridles attached to the exterior edges of the orifice, and substituted a deployment sleeve for the deployment bag to be used with the free fall parachute assembly. It was decided at the conference to accept the revised modification submitted by NAVAERORECOVFAC for test and evaluation. The only other design changes authorized during the conduct of the test program were those required to ensure safe operation or to satisfactorily meet the design parameters.

Pursuant to the action taken at the conference, Headquarters, Naval Air Systems Command issued a revised AIRTASK Problem Assignment No. 036-AE23-74. This directive stated the purpose of the test and evaluation program, based on the parameters and requirements listed below, was to establish the performance characteristics and limitations of this canopy design, and to determine the compatibility of this modified canopy assembly to be deployed from the existing static line parachute container in the A/P28S-14 parachute assembly, and with a deployment sleeve or a bag from the existing free fall container in the A/P28S-13 parachute assembly.

a. Exit velocity capability:

(1) Static Line: 80-130 KIAS.

(2) Free Fall: 80-200 KIAS.

b. Exit altitude capability up to 15,000 feet.

c. Suspended Load: 300 pounds. This is defined as the jumper's total weight, fully equipped, just prior to exit from the aircraft.

d. Sea level descent rate: 17-19.5 ft/sec.

e. Control lines with toggles instead of slip risers for steering.

f. The tests were to provide data on the following performance characteristics:

(1) Rate of descent.

(2) Rate of turn.

(3) Horizontal speed.

(4) Minimum safe deployment altitude at terminal velocity, i.e., vertical fall distance of the parachutist from actuation of the parachute container to a full open parachute.

Purpose. This report presents the final results of the test and evaluation program conducted to determine the performance characteristics of the modified maneuverable personnel canopy assembly, and the compatibility of the modified canopy assembly when used with the A/P28S-14 and A/P28S-13 parachute assemblies.

DESCRIPTION OF EQUIPMENT

Test Item. The item tested was the 35-foot diameter extended skirt canopy assembly: AF 49J7141-2, Type A/P28S-14, Personnel Parachute, Troop-Back, Type T-10, which was modified in the rear with a 7-gore separation "TU" type of orifice and the addition of control lines, FIG. 1. At the canopy, the control lines were attached to the bridles fastened to the canopy radial seams 5 and 6, and 25 and 26, respectively. The other ends of the control lines were attached to the toggles and secured to the front side of the rear risers.

For live jump static line tests this canopy assembly was used with the same deployment bag, AF 56D6276, parachute container, AF 52E6269, risers, AF 59C6174, and harness assembly, AF 59E6173, as furnished with the T-10 Troop-Back Personnel Parachute Assembly, Type A/P28S-14. The packing procedures were in accordance with those outlined in USA TM 10-501-1 (Ref. 1).

For live jump free fall tests this canopy assembly was used with a deployment sleeve, FIG. 3, and the same pilot parachute, AF 60J4249, and harness assembly, AF 60J4371, as furnished with the Free Fall Maneuverable Personnel Parachute Assembly, A/P28S-13. The parachute container used was AF 59J6180 MOD, which had been modified by deleting the requirement for the compartment, mounting bracket, dual housing clamp, and opening in the container for the installation of the automatic ripcord release, Type F-1B. The slip risers were replaced with risers, AF 59C6174. See FIG. 4 for layout of the free fall parachute assembly. Other than packing the canopy assembly in a deployment sleeve, and eliminating the installation of the automatic ripcord release, Type F-1B, the packing procedures utilized were the same as those described in USA TB 10-517-1 (Ref. 2) for the Type A/P28S-13 parachute assembly.

Launch Aircraft. C-47, C-130, and B-66 aircraft were used to launch the torso dummies. The live jump tests were made from U-1B, C-47, C-130, and A-3B aircraft.

Launch Devices. The following special equipment was employed to launch the test dummies individually:

a. A launch board mounted on a hand truck was used to launch the dummies from the side door of the C-47 aircraft.

b. A rack, which divided the bomb bay into four compartments, was used to launch dummies from the B-66 aircraft.

Test Loads. On the dummy tests, torso dummies with gross weights of 250 and 300 pounds were utilized as the test loads. Live jumps were made by test parachutists of this Facility and parachutists from units of NAVOPSUPPGRULANT and NAVOPSUPPGRUPAC. Lead shot containers in various weight increments were used on turn rate and rate of descent tests to ballast each parachutist exactly to gross weights of 200, 250, and 300 pounds. On all other tests, the test load was the gross weight of each jumper with the normal parachutist's equipment. This load varied from 185 to 275 pounds.

Parachutist's Equipment. All test parachutists were equipped with a 26-foot rollpack reserve parachute with instrument mount panel containing a stop watch and an altimeter; jump suit, jump boots, helmet, and goggles. For turn rate tests, each jumper carried a compass.

Photographic Equipment. The following camera equipment was used:

a. A minimum of three Askania cinetheodolite cameras were used to obtain space positioning data.

b. One Contraves cinetheodolite camera was used to determine event times.

c. 16-mm motion picture cameras were used for all ground-to-air, plane-to-air, and air-to-air coverage. Color film was used at exposure rates of 50, 64, 100, 128 and 200 frames per second. Still photographs were taken with a Speedgraphic camera.

Telemetric (TM) Equipment. Telemetric equipment was used in conjunction with the main riser strain gauge links to obtain individual riser forces during parachute deployment and opening.

Permeability Measurement Equipment. Permeability measurements were made on the 1.1 ounce canopy material using a Frazier permeability measuring machine. The permeability was obtained by calculating the flow of air in cubic feet per minute per square foot of the canopy material with a 0.5 inch water pressure differential between the two sides of the material.

SCOPE OF TESTS

The modified canopy assembly design was tested and evaluated under the established parameters to determine its performance characteristics and limitations, and its capability to deploy satisfactorily in a static line or a free fall configuration. Since this modification could significantly affect the operational requirements of the parachute assembly, the canopy was tested in the same manner as a new item. A summary of the test conditions is shown in Table 1.

METHODS OF TESTS

The test methods were based on the specifications contained in enclosure (1) to letter BUAER AER-AE523/86 of 2 June 1955, subject: "Criteria for Test and Evaluation of Personnel Parachutes and Parachute Components; establishment of", and were conducted in consonance with the parameters and requirements established for the program.

Test Procedures - Torso Dummy Tests. Permeability tests were made of all canopies used on twisted line, opening force, low altitude, and high altitude performance tests.

Twisted Line Tests. The tests were started with four new canopy assemblies. Each canopy assembly, FIG. 1, was packed, generally, in accordance with the procedures outlined in USA TB 10-517-1 (Ref. 2) for the A/P28S-13 parachute assembly, using a pilot parachute AF 60J4249, except that a deployment sleeve, FIG. 3, was used in lieu of the deployment bag, AF 61J4453, which is integral to the canopy assembly, AF 58K6360. Risers, AF 59C6174, were substituted for the slip risers. The tests were conducted, as prescribed in RDB Standard A-1, enclosure (1), to the directive referred to in "Methods of Tests". Since a deployment sleeve was used instead of a deployment bag, it was necessary to place the three 360-degree twists in either direction, in the suspension lines immediately below the canopy skirt, rather than at the point where the sleeve is closed, to obtain

the proper test condition. Dummies were launched individually from the side door of the C-47 aircraft. Each dummy was placed in a chest down, base aft position on the launch board. When the rear end of the board was lifted, the dummy slid off. This method of launching minimized the dummy tumbling and rotation. After exit of the dummy, the parachute container was opened by an 18-foot static line attached to the aircraft. The static line was rigged to break one turn of No. 5 cord doubled, which permitted the parachute container to open. See FIG. 5 for installation.

Opening Force Tests. The tests were started with four new canopy assemblies. Each canopy assembly, FIG. 1, was packed, generally, in accordance with the procedures outlined in TB 10-517-1 (Ref. 2), using a pilot parachute, AF 60J4249, except that a deployment sleeve, FIG. 3, was employed for 51 tests, and a deployment bag, FIG. 6, was used for 10 tests instead of the deployment bag, AF 61J4453. Strain gauge risers, AF 62C1254, were substituted for slip risers for use in conjunction with telemetric equipment to obtain individual riser forces during parachute deployment and opening. See FIG. 5.

For those tests where the torso dummies were launched at airspeeds of 80, 110, 125 KIAS, a C-47 aircraft was used. The sequence of events during the drop tests was the same as that described for the twisted line tests.

A B-66 aircraft equipped with four compartments in the bomb bay was used for drop tests made in the airspeed ranges of 150 through 225 KIAS. One dummy was loaded in each compartment. The dummies were released individually in a chest down, base aft attitude during successive passes over the drop zone. An arming cable assembly 18 inches long attached to the bomb bay, actuated a Master Specialties Automatic Parachute Ripcord Release incorporating a 0.75 second delay cartridge, as the dummy left the aircraft.

Opening force data was obtained by measuring, transmitting, and recording with telemetry the output from the strain gauges. Event times were obtained from the Contraves film and the binary time code recorded on the motion picture film.

High Altitude Performance Tests. The tests were started with four new canopy assemblies. The canopy assemblies were packed, generally, in accordance with the procedures outlined in TB 10-517-1 (Ref. 2), using a pilot parachute, AF 60J4249, except that a deployment sleeve, FIG. 3, was employed for 42 tests and a deployment bag, FIG. 6, was

used on 25 tests in lieu of the deployment bag, AF 61J4453. Strain gage risers were substituted for the slip risers.

The C-47 aircraft was used to launch dummies at airspeeds of 110 and 125 KIAS at pressure altitudes of 5,000 and 10,000 feet. The sequence of events was the same as that previously described for launching dummies from C-47 aircraft.

The C-130 aircraft was used to launch dummies at airspeeds of 110 and 125 KIAS at a pressure altitude of 15,000 feet, and at an airspeed of 150 KIAS and a pressure altitude of 5,000 feet. On these drop tests, the dummies were placed in an upright position, approximately six inches from the left of the ramp, and then pushed out chest first. After exit from the aircraft, the parachute container was opened by an 18-foot static line attached to the aircraft. The static line was rigged to break one turn of No. 5 cord doubled, which permitted the parachute container to open. See FIG. 5.

The B-66 aircraft was used to launch dummies at airspeeds of 150, 175, 200, and 225 KIAS at pressure altitudes of 5,000, 10,000, and 15,000 feet. The sequence of events was the same as that previously described for launching dummies from B-66 aircraft.

Test Procedures - Live Jump Tests. The tests were started with 14 new canopy assemblies. The test parachutists assumed a stable prone position as they left the aircraft. In a stable prone position the body is facing downward legs spread, arms extended to the side, and head back.

Static Line Tests. For static line jumps from C-47, C-130, and U-1B aircraft, the canopy assemblies were packed in accordance with the procedures described in USA TM 10-501-1 (Ref. 1), using the same deployment bag, AF 56D6276, parachute container, AF 52E6269, and harness assembly, AF 59E6173, as furnished with the A/P28S-14 parachute assembly. As a safety measure on the C-47 aircraft to prevent fouling of the canopy on the aircraft, a 5-foot static line extension, AF 53D6887, as described in USAF TO 14D1-2-73 (Ref. 3), was attached to the standard static line. The gross weight of the parachutists, equipped with the normal parachutist's equipment, varied from 185 to 275 pounds. A total of 150 tests were completed.

Free Fall Tests. During free fall jumps from U-1B, C-47, and A-3B aircraft, the canopy assemblies were packed, generally, in accordance with the procedures outlined in TB 10-517-1 (Ref. 2), except that a

deployment sleeve, FIG. 3, was used. The same pilot parachute, AF 60J4249, and harness assembly, AF 60J4371, as furnished with parachute assembly, A/P28S-13, and the parachute container, AF 59J6180 MOD, were employed. The slip risers were replaced with risers, AF 59C6174. FIG. 7 shows the parachute during descent.

A total of 36 turn rate tests were conducted from the C-47 aircraft. Test parachutists with gross weights of 200, 250, and 300 pounds performed various maneuvers such as turning and braking after parachute opening. Turns of 180 and 360 degrees were timed by the jumper using a stop watch and a reference point on the ground. Turn times were obtained, also, from the binary time code recorded on the film of the ground-to-air motion picture cameras. See Table 2.

A total of 130 live jumps were conducted from the U-1B aircraft at airspeeds of 80 and 105 KIAS using jump and pull, 5 second, and 20 second delay methods. The gross weight of the jumpers varied from 185 to 275 pounds.

Twenty live jumps were made from U-1B and C-47 aircraft at airspeeds of 100 and 110 KIAS at a pressure altitude of 7,000 feet with a 15 second time delay to determine the vertical fall distance from manual parachute actuation to full open parachute after terminal velocity had been reached. Mounted on the container was a flashbulb arrangement, which was illuminated when the parachutist pulled the ripcord. See FIG. 8. Data was acquired from Askania and Contraves cinetheodolite cameras, and the binary time code on film used in the ground-to-air motion picture coverage.

Five live jumps were made from an A-3B aircraft at an airspeed of 200 KIAS at a pressure altitude of 10,000 feet. On these tests, a Master Specialties Automatic Parachute Ripcord Release with a 10 second delay was employed. The release was actuated upon exit of the jumper from the aircraft.

RESULTS AND DISCUSSION

1. The results of the permeability measurements tests are shown in Table 3.

2. The results of the twisted line tests indicated the parachute would fully inflate with twisted lines and attain equilibrium prior to ground impact of the dummy load.

3. The results of the torso dummy drop tests conducted at an absolute altitude of 1,000 feet to acquire data on opening forces, time from container opening to a full open parachute, and the vertical fall distance from container opening to a full open parachute are shown in Table 4, and FIG. 9 through FIG. 11.

There was normal deployment and opening of the canopy in 60 of the 61 tests. All canopies which sustained minor damage, still had an acceptable rate of descent.

In describing damage to the canopies, "minor damage" is defined as small tears, holes, strains, and friction burns; "major damage" refers to extensive damage that prevented full inflation of the canopy.

Deployment sleeve tests. Minor damage occurred to the canopies during 9 of the 47 tests conducted within the test parameters of 80 to 200 KIAS. During these tests there were no canopies damaged at airspeeds below 150 KIAS. Minor damage was incurred by three canopies at 150 KIAS, two canopies at 175 KIAS, and four canopies at 200 KIAS. At 225 KIAS three canopies received minor damage, and one had major damage. Deployment of the latter canopy appeared normal, however, the canopy failed to inflate fully because of the extensive damage. This latter canopy had undergone 12 previous drop tests at launch speeds varying from 80 to 200 KIAS. Minor damage consisted of friction burns and small holes, evidently caused during extraction of the canopy from the deployment sleeve. Major damage to the one canopy consisted of 7 blown panels and broken suspension lines numbered 13 through 17.

Deployment bag tests. Minor damage occurred during two of the ten tests. One canopy was damaged at 175 KIAS, and one canopy at 200 KIAS. Damage consisted of friction burns, small holes, and strains, apparently occurring during extraction of the canopy from the deployment bag.

4. The results of the torso dummy drop tests conducted at various pressure altitudes to acquire data on opening forces, time from container opening to full open parachute, and the vertical fall distance from container opening to a full open parachute are shown in Table 5.

There was normal deployment and opening of the canopy in 66 of the 67 tests. All canopies which sustained minor damage, still had an acceptable rate of descent.

Deployment sleeve tests. Minor damage occurred to the canopies during 7 of the 39 tests conducted within the test parameters of 80 to 200 KIAS. During these tests there were no canopies damaged at airspeeds below 150 KIAS. Minor damage was incurred by two canopies at 150 KIAS, three canopies at 175 KIAS, and two canopies at 200 KIAS. One of the canopies at 175 KIAS had a blown gore but remained fully inflated. This latter canopy had undergone 11 previous drop tests at launch speeds varying from 110 to 175 KIAS. At 225 KIAS three canopies had minor damage. Minor damage consisted of friction burns and small holes, apparently caused during extraction of the canopy from the deployment sleeve.

Deployment bag tests. There were no canopies damaged at airspeeds below 150 KIAS. Minor damage occurred to the canopies during 4 of the 21 tests launched within the test parameters of 80 to 200 KIAS. Minor damage was incurred by two canopies at 150 KIAS and two canopies at 175 KIAS. One canopy had major damage at 175 KIAS. Deployment of the latter canopy appeared normal, however, the canopy failed to inflate fully because of the extensive damage. Damage consisted of one blown gore, 17 blown panels, friction burns, and small holes. This canopy had undergone 10 previous drop tests at launch speeds varying from 110 to 175 KIAS. One canopy had damage at 200 KIAS consisting of large holes in six panels, small holes, and severe friction burns. Deployment appeared normal and the canopy remained inflated. This canopy had undergone six previous drop tests at launch speeds varying from 150 to 200 KIAS. At 225 KIAS two canopies had minor damage. Minor damage to the canopies consisted of friction burns and small holes, apparently occurring during extraction of the canopy from the deployment bag

During four of the tests which were initiated at an airspeed of 150 KIAS and at a pressure altitude of 15, 000 feet, the parachute containers were opened by an automatic parachute ripcord release after the dummies had fallen to 10, 000-foot altitude. The deployment of the canopy assemblies from two deployment sleeves and two deployment bags was normal. The canopy assemblies incurred no damage following the delayed opening. On all the other tests, a 0.75 second delay cartridge was used to actuate the ripcord assembly upon release of the dummy from the aircraft.

5. The results of the live jump tests to determine the minimum safe deployment altitude, i.e., the vertical fall distance of the parachutist from the time of ripcord pull to a full open parachute, after terminal velocity had been reached, are shown in Table 6.

6. During both static line and free fall live jump operations, the canopy assemblies functioned satisfactorily. There were no malfunctions or problems encountered, either when the canopy assembly was static line deployed at airspeeds of 80, 110, and 130 KIAS, or during free fall tests initiated at airspeeds of 80 KIAS, using either jump and pull or 20 second time delay, or at 110 KIAS with 5 and 15 second time delays, or at 200 KIAS with a 10 second delay.

7. The testing of the deployment sleeve, selected during the conference referred to in the "Introduction", indicated that the canopy assembly would deploy satisfactorily from the sleeve during free fall operations. It will be noted, also, that some tests were conducted using a deployment bag. These tests indicated the canopy assembly would deploy satisfactorily from a full bag.

CONCLUSIONS

It is concluded:

1. The canopy assembly, as tested, for static line operations at airspeeds of 80 to 130 KIAS, and for free fall operations at airspeeds of 80 to 200 KIAS, is structurally adequate and operationally satisfactory.

2. The canopy assembly, as modified, can be deployed from the A/P28S-14 type of parachute assembly for static line operations.

3. The canopy assembly, as modified, can be deployed from the A/P28S-13 type of parachute assembly with either a deployment sleeve or deployment bag for free fall operations.

4. The canopy assembly, as modified, provides a faster turning, and thus a more maneuverable parachute assembly than the Parachute Assembly A/P28S-10 (Ref. 4) and A/P28S-13 (HALO) (Ref. 2); i.e., a turn rate of approximately 4.5 seconds vs 9 seconds for 180-degree turns, and a forward speed of approximately 14 feet/second vs 6 feet/second.

5. The rate of descent range (16.14 to 20.22 feet/second) was adjudged acceptable and sufficiently within the performance specified for a 300-pound parachutist.

RECOMMENDATIONS

It is recommended that:

1. The deployment sleeve be used with the parachute assembly for free fall operations.

2. This canopy assembly not be used at exit speeds higher than 130 knots for static line operations. This limitation is compatible with the operational limitations delineated in Reference 4, since this assembly is similar in construction and in configuration.

3. Organizations employing this canopy assembly consult USA TM 57-220 (Ref. 5) and AFM 55-Series/Aircraft (Ref. 6) for information on the operational techniques, procedures, and limitations pertaining to parachuting with the A/P28S-10 and A/P28S-13 types of parachute assemblies from Army and Air Force aircraft, and applicable aircraft in the Navy inventory.

REFERENCES

1. USA TM 10-501-1, Army Parachutes Packing, Troop-Back Personnel Parachutes (T-10 and Maneuverable)

2. USA TB 10-517-1, Parachutes: Packing of Parachute Assembly, Free Fall, Single Orifice, Chest and Back, 35-Foot Diameter Main and 24-Foot Diameter Reserve, Type A/P28S-13 (HALO)

3. USAF T. O. 14D1-2-73, Parachutes: Packing and Maintenance of Parachute, Personnel, Troop-Back, 35-Foot Diameter, Nylon Canopy, Type T-10

4. USAF T. O. 14D1-2-171, Personnel Parachute, Type A/P28S-10

5. USA TM 57-220, Technical Training of Parachutists

6. AFM 55 - Series/aircraft, Operational Procedures

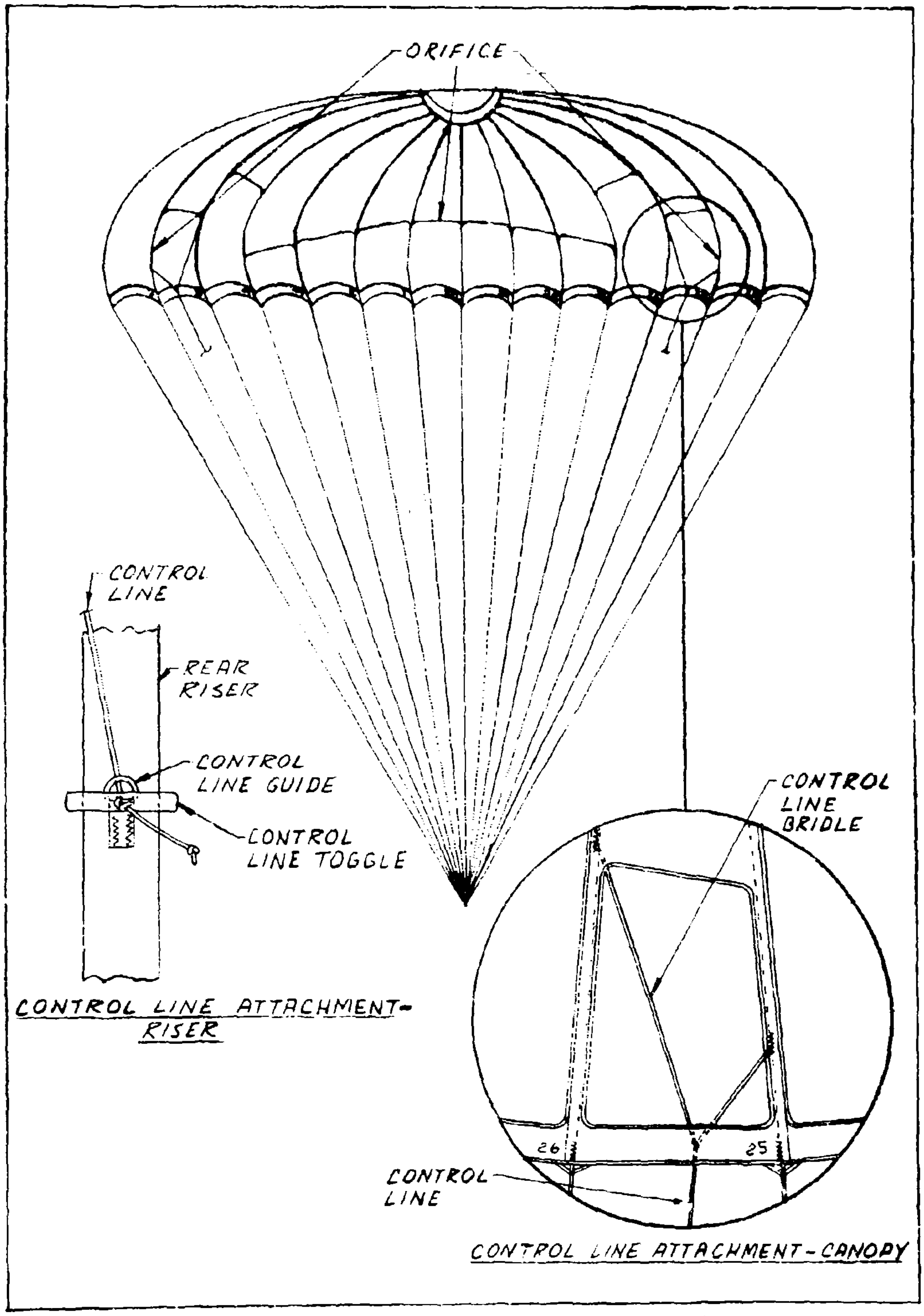

FIG. 1. Canopy Modification and Control Lines Installation.

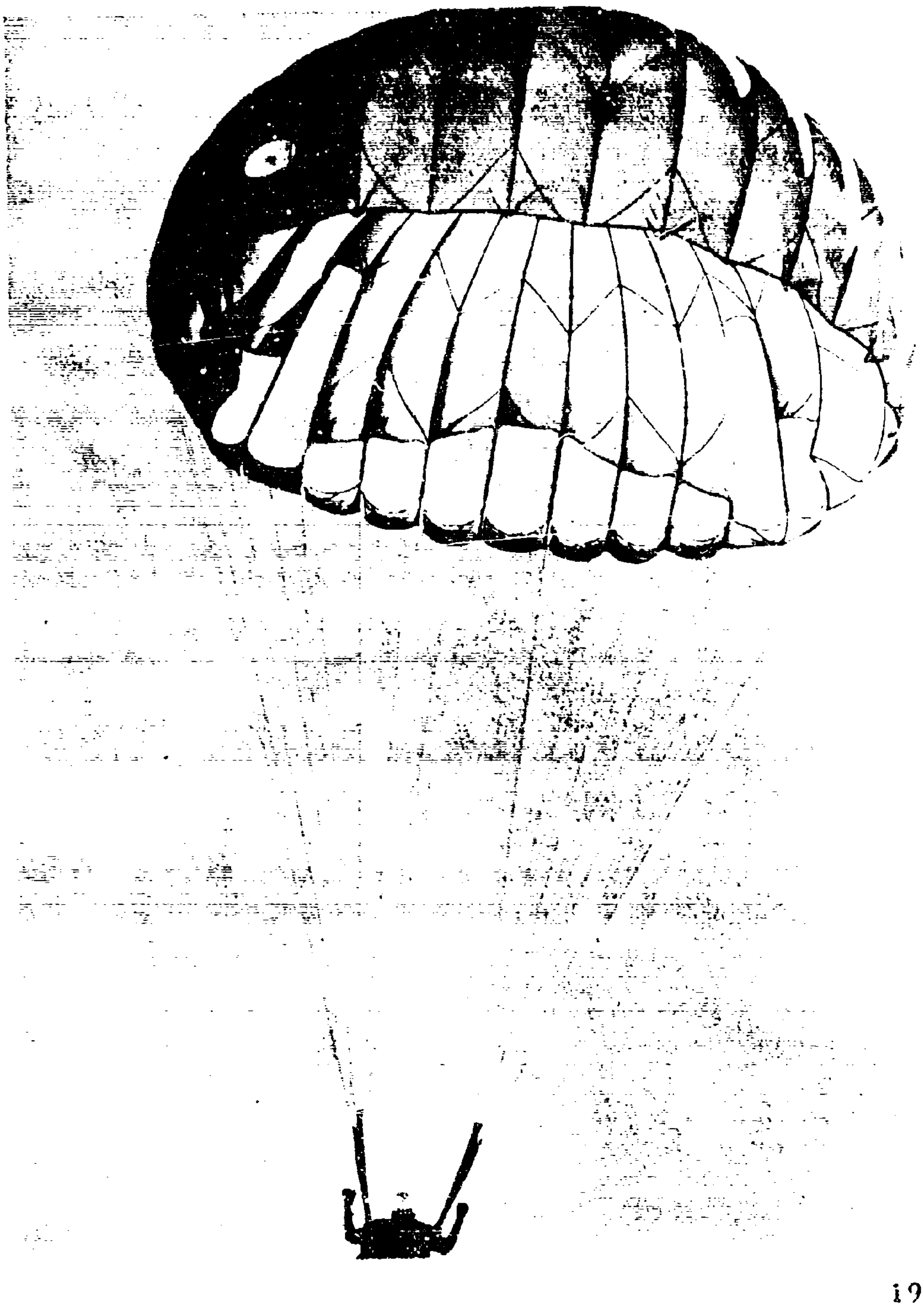

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FIG. 2. Inflated Modified Canopy During Descent.

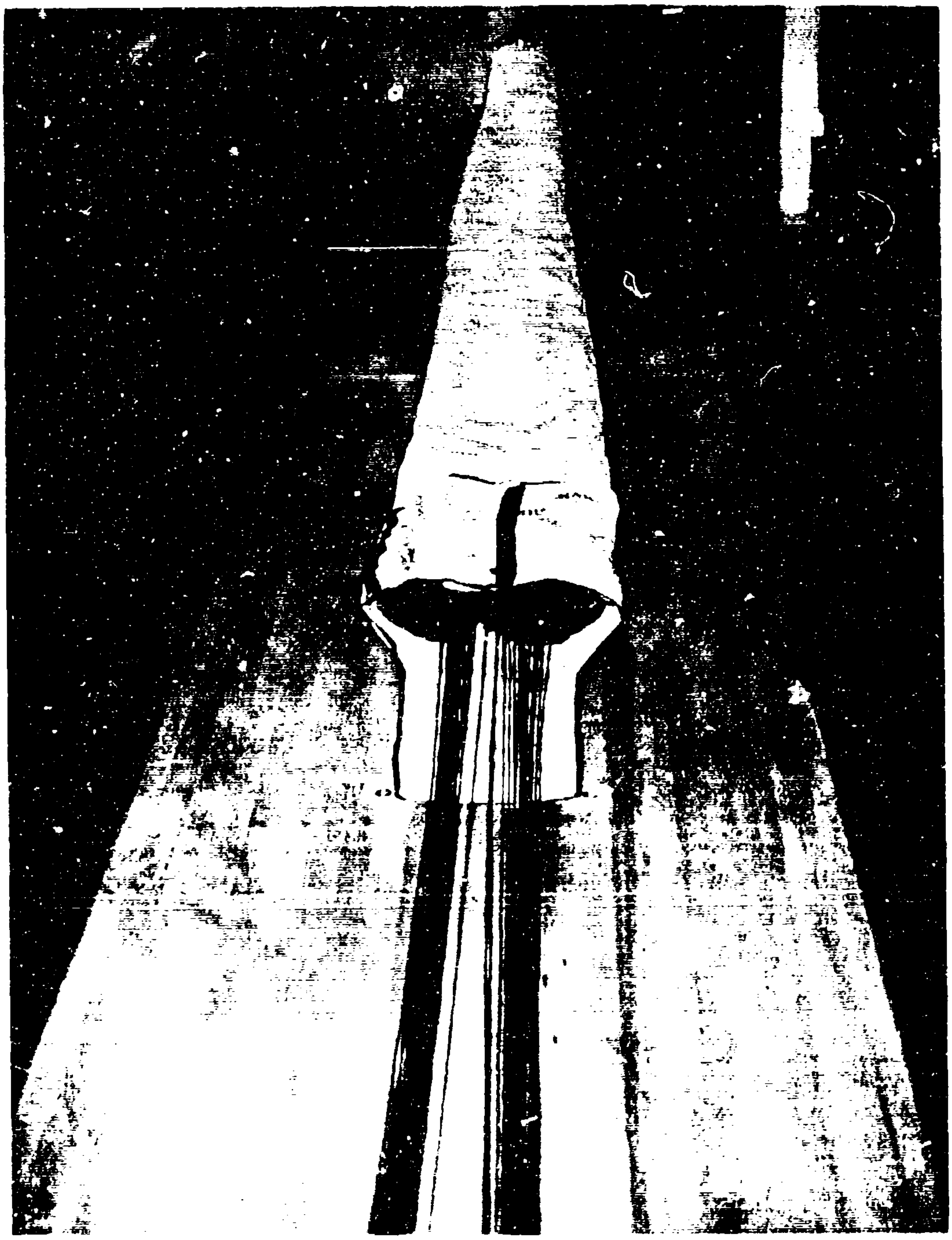

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FIG. 3. Canopy Assembly Laid Out in Deployment Sleeve.

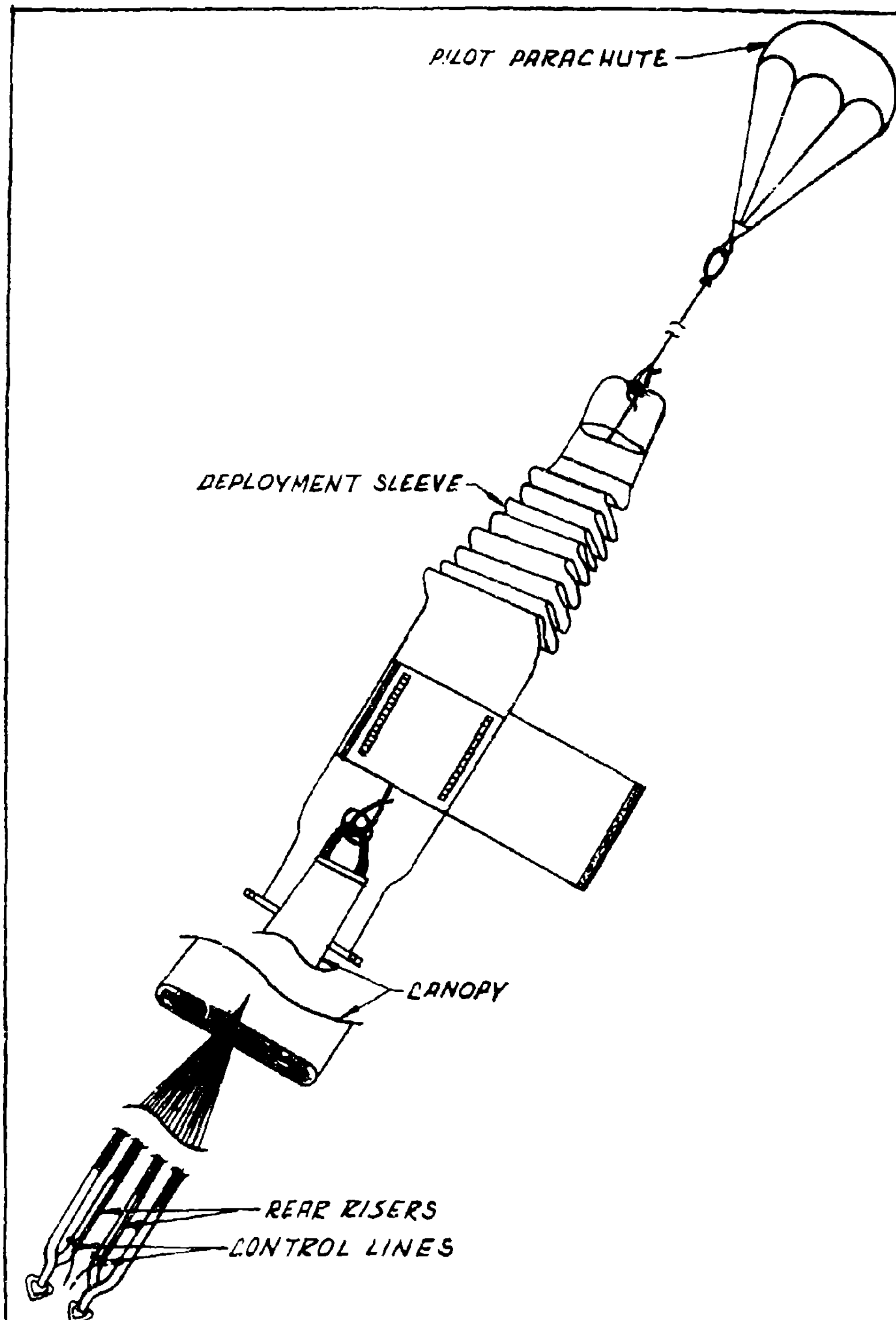
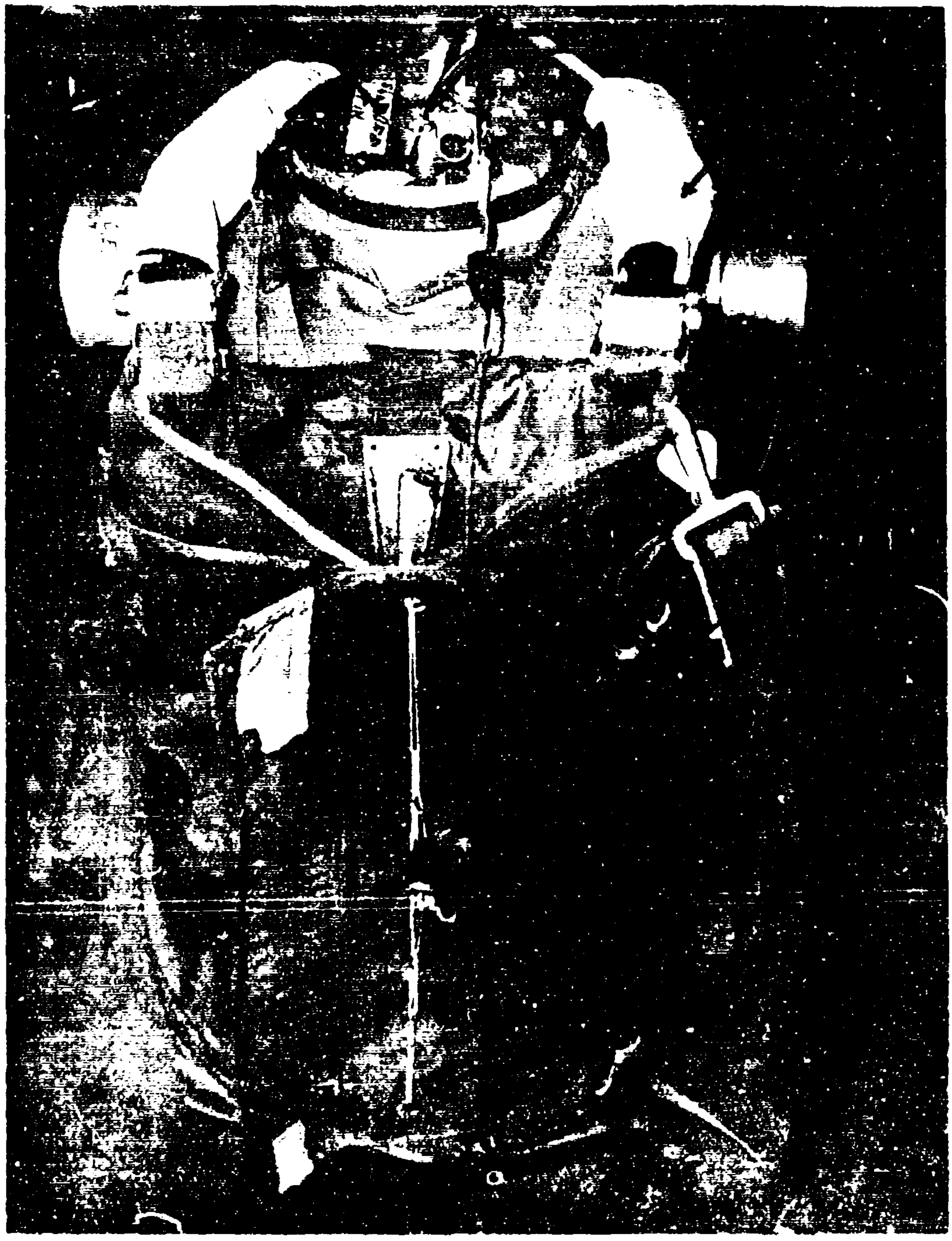


FIG. 4. Layout of Free Fall Parachute Assembly.

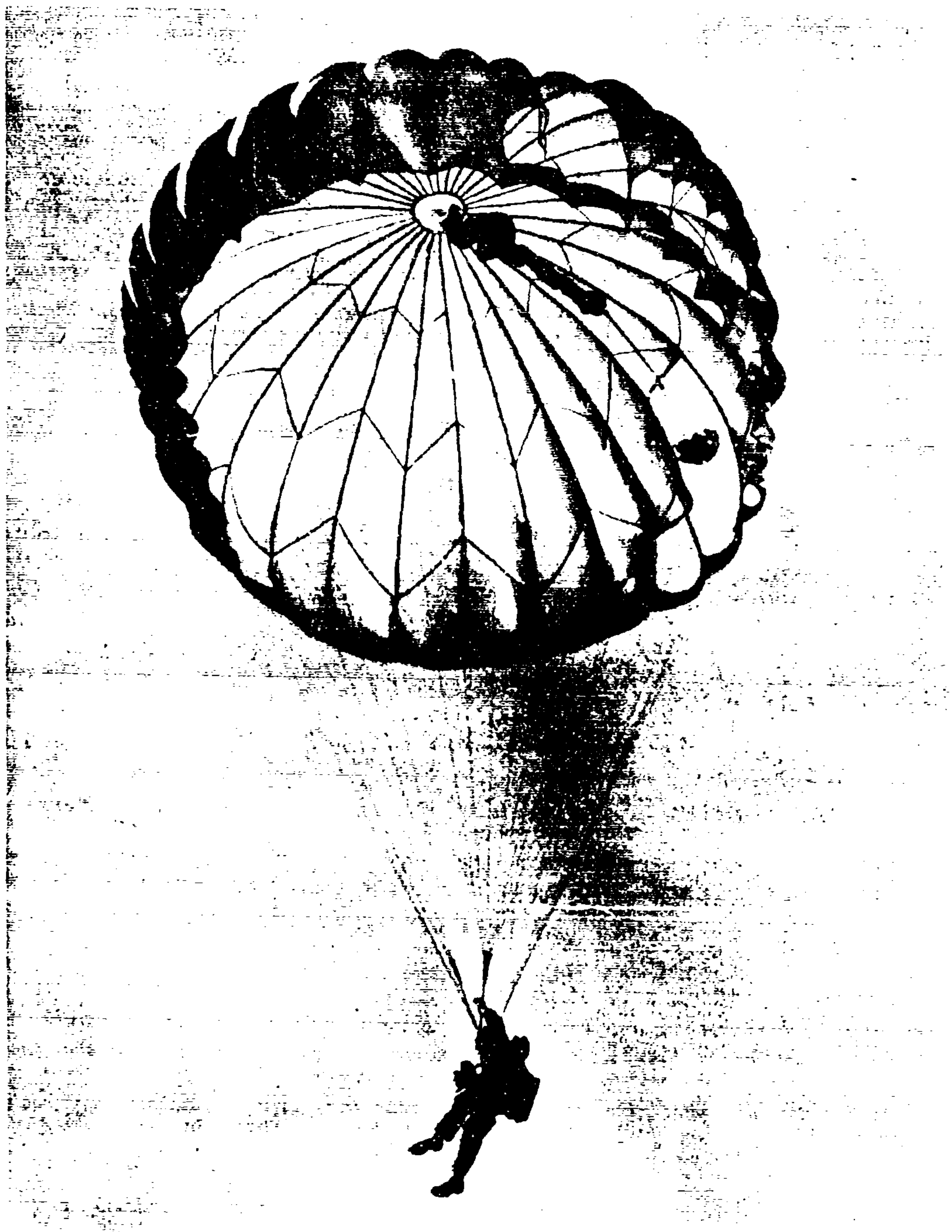


21329

FIG. 5. Container Assembly Attached to Torso Dummy-Static Line Attachment and Telemetry Installation.

23742

FIG. 6. Canopy Assembly Laid Out in Deployment Bag.



19410

FIG. 7. Modified Maneuverable Personnel Parachute During Descent.

22153

FIG. 8. Flashbulb Installation Mounted on Parachute Container.

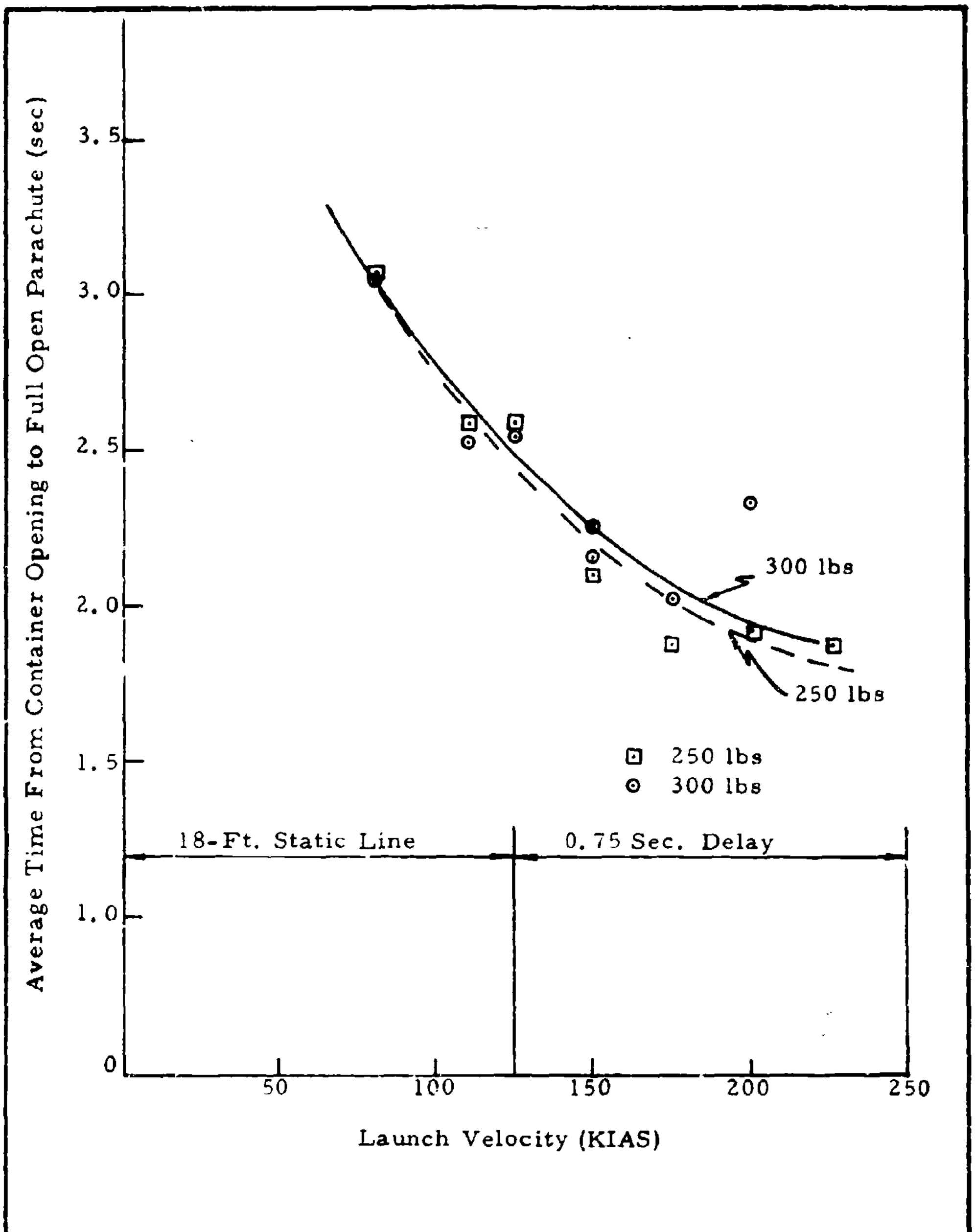


FIG. 9. Average Time From Container Opening to Full Open Parachute vs Launch Velocity at 1,000-Ft. Absolute Altitude.

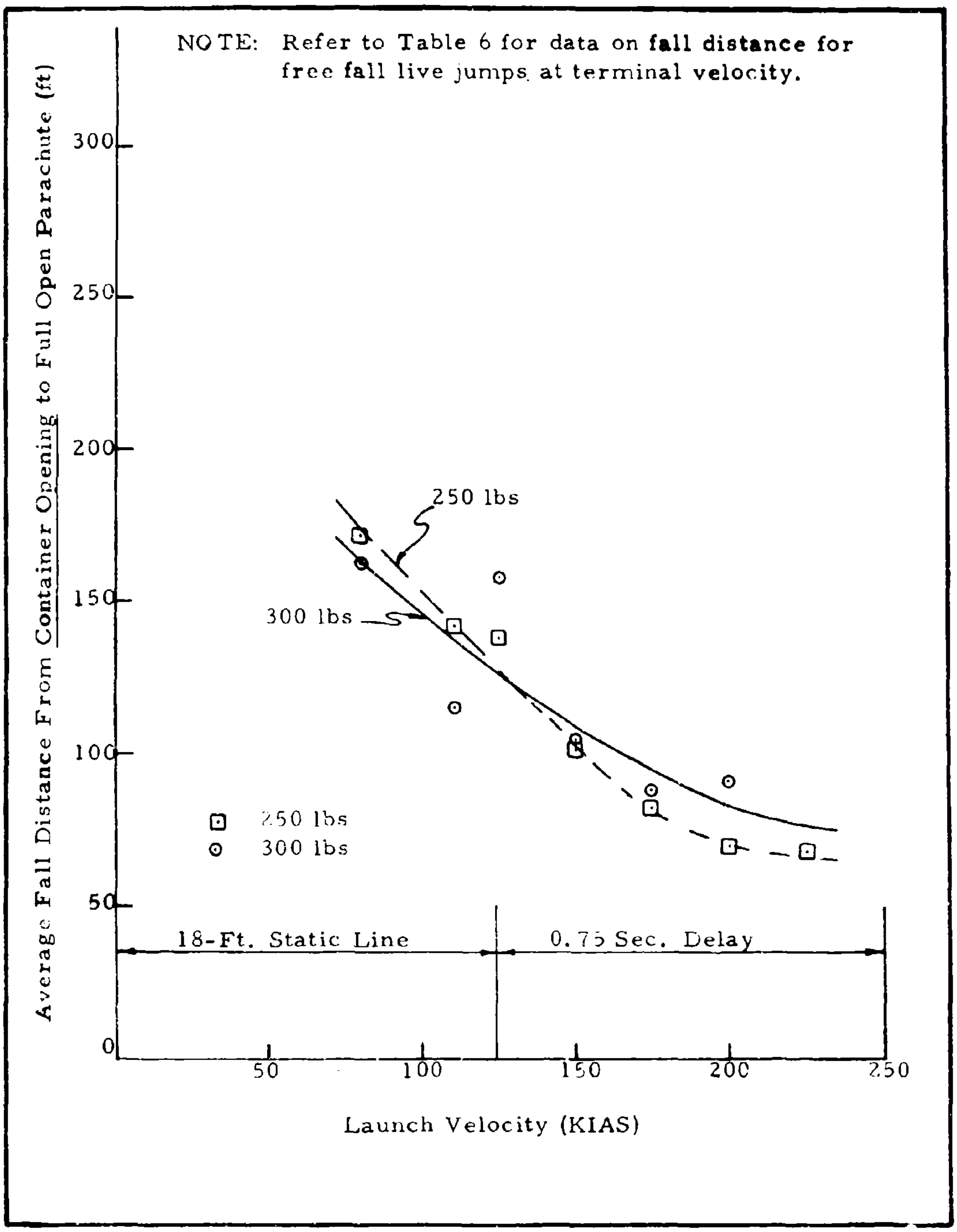


FIG. 10. Average Fall Distance From Container Opening to Full Open Parachute vs Launch Velocity at 1,000-Ft. Absolute Altitude.

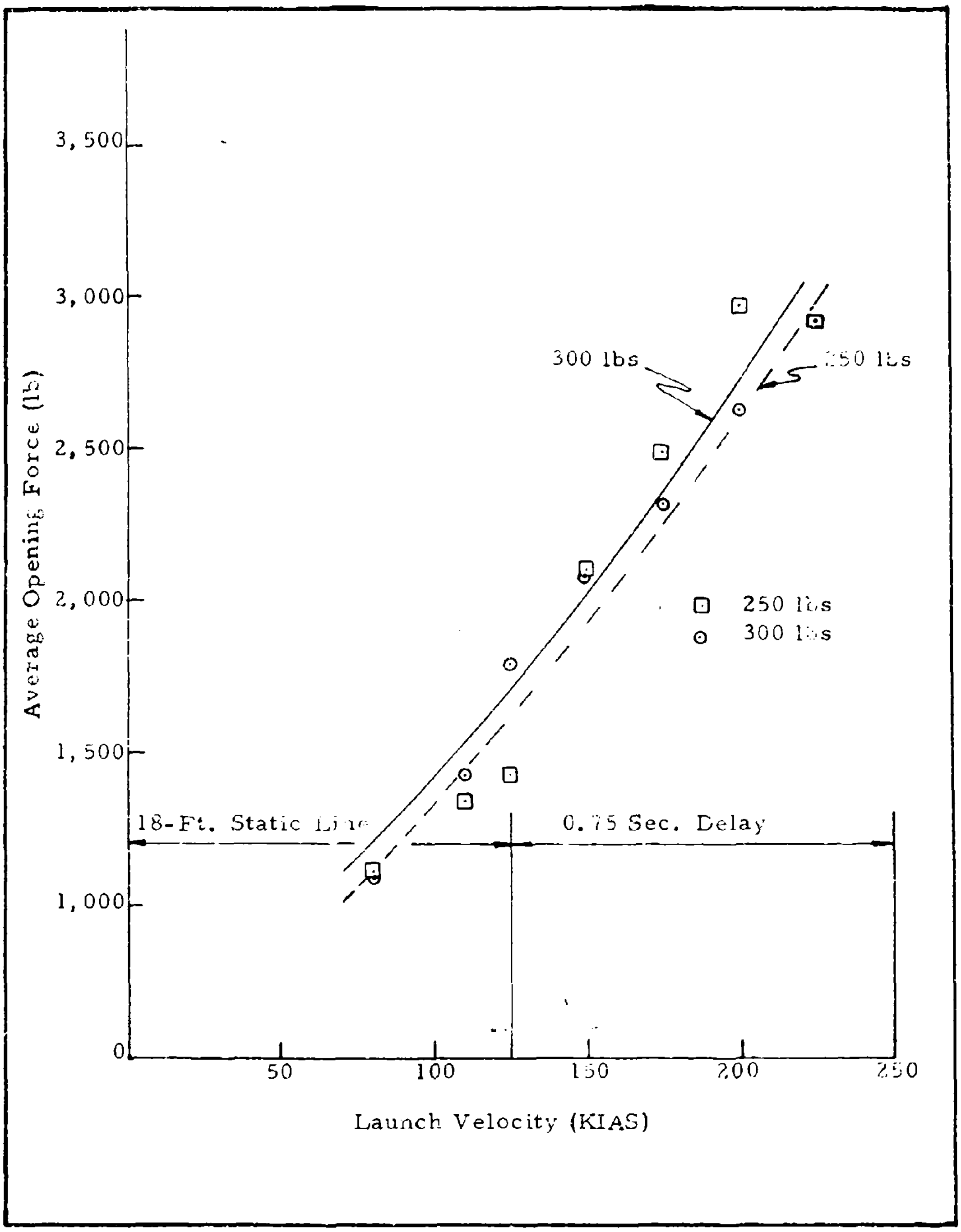


FIG. 11. Average Maximum Opening Force - Total Both Parachute Risers vs Launch Velocity at 1,000-Ft. Absolute Altitude.

TABLE 1. Test Conditions for Evaluation of Modified Canopy Assembly - Maneuverable Personnel Parachute

Test Phase	Total No. of Tests	No. of Parachutes (min)	Speed (KIAS)	Time Delay (sec)	Altitude (ft)	Gross Weight (lbs)	Special Test Conditions
1. Twisted Line	10	4	80	static line	500	300	Torso dummy. Free fall static line activation.
	30	4	110	" "	500	300	
2. Reliable safe opening altitude and opening force	4	4	80	" "	1,000	250	Torso dummy with instrumentation to record opening forces. Free fall static line activation.
	4	4	80	" "	1,000	300	
	4	4	110	" "	1,000	250	
	4	4	110	" "	1,000	300	
	4	4	125	" "	1,000	250	
	4	4	125	" "	1,000	300	
	4	4	150	" "	1,000	250	
	4	4	150	" "	1,000	300	
	4	4	175	" "	1,000	250	
	4	4	175	" "	1,000	300	
	4	4	200	" "	1,000	250	
	4	4	200	" "	1,000	300	
	4	4	225	" "	1,000	250	
	4	4	225	" "	1,000	300	

TABLE 1 (Contd.)

Test Phase	Total No. of Tests	No. of Parachutes (min)	Speed (KIAS)	Time Delay (sec)	Altitude (ft)	Gross Weight (lbs)	Special Test Conditions
3. High altitude	4	4	110	static line	5,000	300	Torso dummy with instrumentation.
	4	4	110	" "	10,000	300	Free fall static line activation.
	4	4	110	" "	15,000	300	
	4	4	125	" "	5,000	300	
	4	4	125	" "	10,000	300	
	4	4	125	" "	15,000	300	
	4	4	150	" "	5,000	300	
	4	4	150	" "	10,000	300	
	4	4	150	" "	15,000	300	
	4	4	175	" "	5,000	300	
	4	4	175	" "	10,000	300	
	4	4	175	" "	15,000	300	
	4	4	200	" "	5,000	300	
	4	4	200	" "	10,000	300	
	4	4	200	" "	15,000	300	
	4	4	225	" "	5,000	300	
	4	4	225	" "	10,000	300	
	4	4	225	" "	15,000	300	

TABLE 1 (Contd.)

Test Phase	Total No. of Tests	No. of Parachutes (min)	Speed (KIAS)	Time Delay (sec)	Altitude (ft)	Gross Weight (lbs)	Special Test Conditions
4. Live jump							
a. Turn rate	30	6	110	jump & pull	6,000	200/250/300	
b. Rate/descent, horizontal speed, oscillation	60	6	110	" "	6,000	200/250/300	
5. Live jump							
a. Reliability	50	10	80	static line	5,000	Jumper	
	50	10	110	" "	5,000	"	
	50	10	130	" "	8,000	"	
	50	10	80	jump & pull	5,000	"	
	40	10	110	5 second	5,000	"	
	40	10	110	10 second	7,000	"	
	5	2	200	10 second	10,000	"	
b. Minimum safe deployment altitude at terminal velocity	20	5	110	15 second	7,000	"	

TABLE 2. Results of Live Jump Turn Rate Tests [a]

Gross weight of parachutist	Time Parachutist with Stopwatch		Time Binary Time Code Camera		Av. Horizontal speed	Av. Oscillation	Rate of descent MSL
	180° turn	360° turn	180° turn	360° turn			
(lbs)	(sec)	(sec)	(sec)	(sec)	(ft/sec)	(degrees)	(ft/sec)
C-47 Aircraft @ 110 KIAS -- 6,000 ft. pressure altitude							
200	4.42	7.88	4.88	9.63	13	2.81	16.14
250	4.15	6.62	4.44	7.61	13.8	3.01	18.37
300	4.37	8.32	4.38	8.98	14.6	3.22	20.22

[a] Turn time is the time, in seconds, required for the parachutist to complete a 180-degree turn, or a 360-degree turn.

TABLE 3. Results of Permeability Tests Made on Parachute Canopy Material

NARF Parachute Serial No.	Number Previous Times Dropped	Canopy Material Permeability Panel A (cfm/ft^2)	Panel B (cfm/ft^2)	Panel C (cfm/ft^2)	Panel D (cfm/ft^2)	Test Conditions [a]	
01496	0	114.2	99.6	101.6	98.2	72	63%
01498	0	107.9	107.2	106.5	111.2	72	63%
01500	0	104.4	102.3	106.5	93.3	72	63%
01501	0	113.0	113.6	117.2	118.4	72	63%
01495	0	120.2	100.9	123.2	120.8	71	62%
01497	0	103.7	109.3	103.0	93.3	71	62%
01489	0	127.4	111.8	110.6	105.8	71	62%
01502	0	94.7	91.2	94.0	91.8	71	62%
01499	0	101.3	102.15	100.88	121.72	60	74%
01550	0	100.81	109.22	102.66	104.72	73	48%
01551	0	115.55	116.0	116.75	125.93	76	41%
01552	0	101.3	102.15	100.88	121.72	73	42%
01554	0	135.47	132.92	143.05	109.43	73	42%

[a] Percentage figures indicate the relative humidity at the time of the test.

TABLE 4. Section 1. Results of Opening Force Tests Using 300-lb. Torso Dummies Launched at 1,000 Ft. Absolute Altitude

Drop No.	Time		Fall Distance		Maximum Riser Forces[b]			Rate of descent MSL
	Container open to full open (sec)	Container open to equilibrium[a] (sec)	Container open to full open (ft)	Container open to equilibrium[a] (ft)	Right (lb)	Left (lb)	Total (lb)	(ft/sec)
C-47 Aircraft @ 80 KIAS -- 18 Ft. Static Line Actuation								
3778N	2.85	8	156	241	660	540	1,190	19.76
3779N	3.07	8	156	233	NA	NA	NA	20.22
3780N	3.38	7	187	253	565	605	1,070	17.56
3781N	2.83	8	156	259	470	580	1,040	19.33
C-47 Aircraft @ 110 KIAS -- 18 Ft. Static Line Actuation								
3766N	2.26	8	110	216	815	780	1,600	18.71
3767N	2.68	6.5	127	226	780	640	1,400	19.07
3768N	2.27	8	85	202	700	870	1,560	18.80
3769N	2.92	10	140	243	500	700	1,140	18.58
C-47 Aircraft @ 125 KIAS -- 18 Ft. Static Line Actuation								
3786N	4.05	9	157	225	890	960	1,750	19.18
3787N	2.48	5	123	194	960	750	1,720	19.44
3788N	2.40	8	223	210	945	865	1,780	19.04
3789N	2.78	10	133	259	870	1,040	1,920	18.75

TABLE 4. Section 1 (Contd.)

Drop No.	Time: Container open to full open (sec)	Time: Container open to equilibrium [a] (sec)	Fall Distance: Container open to full open (ft)	Fall Distance: Container open to equilibrium [a] (ft)	Maximum Riser Forces [b]: Right (lb)	Maximum Riser Forces [b]: Left (lb)	Maximum Riser Forces [b]: Total (lb)	Rate of descent MSL (ft/sec)
B-66 Aircraft @ 150 KIAS -- Automatic Ripcord Release With 0.75 Sec. Delay Actuation								
3794N	2.02	9	105	207	1,300	1,025	2,250	16.63
3795N	2.13	7	121	212	890	1,000	1,900	19.70
3796N	2.37	7	74	189	1,100	1,300	1,900	17.78
3798N	2.53	7	113	201	1,050	955	2,000	16.69
3799N	2.04	8.5	96	286	965	1,025	1,980	20.64
3800N	2.11	9.5	97	235	1,230	1,040	2,270	21.12
3819N [c]	2.50	8	174	248	NA	775	NA	19.73
3820N [c]	1.53	5	63	131	1,100	1,225	2,300	18.01
B-66 Aircraft @ 175 KIAS -- Automatic Ripcord Release With 0.75 Sec. Delay Actuation								
3804N	2.21	7	104	198	1,065	1,170	2,180	15.47
3805N	1.82	6	85	167	1,260	1,620	2,900	19.40
0478N [c]	2.10	7	82	178	900	950	1,800	20.57
0479N [c]	2.00	8.6	81	183	1,275	1,100	2,375	15.32
B-66 Aircraft @ 200 KIAS -- Automatic Ripcord Release With 0.75 Sec. Delay Actuation								
3806N	1.69	9	71	224	1,575	1,280	2,820	19.30
3807N	2.77	4.5	109	156	1,300	1,770	2,650	21.20
3808N	2.13	8	80	166	1,470	1,060	2,425	16.24
3809N	2.76	4	108	135	1,425	1,250	2,600	18.96

TABLE 4. Section 2. Results of Opening Force Tests Using 250-lb. Torso Dummies Launched at 1,000 Ft. Absolute Altitude

Drop No.	Time: Container open to full open (sec)	Time: Container open to equilibrium[a] (sec)	Fall Distance: Container open to full open (ft)	Fall Distance: Container open to equilibrium[a] (ft)	Maximum Riser Forces[b]: Right (lb)	Maximum Riser Forces[b]: Left (lb)	Maximum Riser Forces[b]: Total (lb)	Rate of descent MSL (ft/sec)
C-47 Aircraft @ 80 KIAS -- 18 Ft. Static Line Actuation								
3774N	2.71	11	186	310	650	645	1,265	17.77
3775N	3.37	6	177	241	500	550	980	17.79
3776N	2.69	6	143	212	400	520	900	17.82
3777N	3.52	10	184	283	810	490	1,300	17.88
C-47 Aircraft @ 110 KIAS -- 18 Ft. Static Line Actuation								
3770N	2.37	9	122	228	1,040	880	1,900	17.60
3771N	4.06	9	158	222	400	490	880	17.15
3772N	2.67	8	163	299	725	790	1,460	18.94
3773N	2.69	10	127	224	640	'80	1,100	17.63
C-47 Aircraft @ 125 KIAS -- 18 Ft. Static Line Actuation								
3782N	2.87	5	130	175	530	800	1,275	17.42
3783N	2.95	8	133	219	690	570	1,240	16.58
3784N	3.19	5	156	168	725	740	1,460	17.40
3785N	2.60	9	133	212	800	880	1,680	16.78

TABLE 4. Section 2 (Contd.)

Drop No.	Time: Container open to full open (sec)	Time: Container open to equilibrium [a] (sec)	Fall Distance: Container open to full open (ft)	Fall Distance: Container open to equilibrium [a] (ft)	Maximum Riser Forces [b]: Right (lb)	Maximum Riser Forces [b]: Left (lb)	Maximum Riser Forces [b]: Total (lb)	Rate of descent MSL (ft/sec)
B-66 Aircraft @ 150 KIAS -- Automatic Ripcord Release With 0.75 Sec. Delay Actuation								
3790N	1.8	10	87	240	1,200	1,295	2,315	20.31
3791N	2.5	7	125	210	960	750	1,650	14.05
3792N	2.5	7	124	196	725	665	1,360	16.08
3793N	1.95	3.1	91	118	1,050	1,360	2,150	17.53
3797N	2.12	6	95	169	990	950	1,940	16.10
3817N [c]	1.73	5	83	173	1,650	1,150	2,750	19.05
3818N [c]	2.23	7	105	220	1,400	1,175	2,575	20.29
B-66 Aircraft @ 175 KIAS -- Automatic Ripcord Release With 0.75 Sec. Delay Actuation								
3801N	1.99	8.6	92	213	1,290	1,200	2,530	19.86
3802N	1.58	4.6	60	122	890	860	1,750	16.45
3803N	2.29	4.8	109	158	1,750	1,230	2,950	16.84
3821N [c]	1.79	5.6	66	158	1,175	1,200	2,310	18.01
0475N [c]	1.70	6.0	82	185	1,375	1,450	2,825	19.43
B-66 Aircraft @ 200 KIAS -- Automatic Ripcord Release With 0.75 Sec. Delay Actuation								
3810N	1.83	5	74	159	1,475	1,285	[illegible]	19.24
3811N	1.80	6	63	132	1,500	1,225	2,750	17.34
3813N	2.03	6	89	183	NA	NA	NA	20.34
0476N [c]	2.40	8	60	226	2,800	2,010	4,800	21.15
0477N [c]	1.60	7	63	186	2,000	1,410	3,400	20.47

TABLE 4. Section 2 (Contd.)

Drop No.	Time: Container open to full open (sec)	Time: Container open to equilibrium [a] (sec)	Fall Distance: Container open to full open (ft)	Fall Distance: Container open to equilibrium [a] (ft)	Maximum Riser Forces [b]: Right (lb)	Maximum Riser Forces [b]: Left (lb)	Maximum Riser Forces [b]: Total (lb)	Rate of descent MSL (ft/sec)
B-66 Aircraft @ 225 KIAS -- Automatic Ripcord Release With 0.75 Sec. Delay Actuation								
3812N	1.50	7	55	172	1,900	2,025	3,950	18.37
3814N	2.34	5	86	158	1,175	1,300	2,325	17.10
3815N	1.79	3	64	104	1,650	2,150	3,800	17.72
3816N [d]	NA	NA	NA	NA	850	725	1,550	NA

[a] Time at which the first minimum rate of descent is attained after parachute reaches full open.

[b] The riser forces are the maximum recorded, but not necessarily at the same instant. The total force is the maximum instantaneous sum of the riser forces.

[c] Deployment bag was used. On all other tests a deployment sleeve was employed.

[d] Canopy incurred major damage.

TABLE 5. Results of Tests at Various Pressure Altitudes Using 300-lb. Torso Dummies

No. of tests avg'l.	Time		Fall Distance		Maximum Riser Forces[c]			Rate of descent MSL
	Container open to full open[a] (sec)	Container open to equilibrium[b] (sec)	Container open to full open (ft)	Container open to equilibrium[b] (ft)	Right (lb)	Left (lb)	Total (lb)	(ft/sec)
C-47 Aircraft @ 110 KIAS -- 5,000 ft. altitude								
4	2.47	4.75	101.2	161	820	862.5	1582.5	19.06 (3 tests)
C-47 Aircraft @ 110 KIAS -- 10,000 ft. altitude								
4	2.35	4.43	107.45	153.25	893.75	1037.5	1850	19.24
C-130 Aircraft @ 110 KIAS -- 15,000 ft. altitude								
4	2.13	2.87	98.57	128.75	1100 (3 tests)	925	2025 (3 tests)	NA
C-47 Aircraft @ 125 KIAS -- 5,000 ft. altitude								
4	2.63	5.2	116.2	187.5	945	868.7	1795	20.96
C-47 Aircraft @ 125 KIAS -- 10,000 ft. altitude								
4	2.44	4.2	111.8	160.9	1000	963	1855	18.32
C-130 Aircraft @ 125 KIAS -- 15,000 ft. altitude								
3	2.06	3.0	110.3	141	1171	1191	2243	NA
C-130 Aircraft @ 150 KIAS -- 5,000 ft. altitude								
4	2.69	5.7	121.9	209	1287	1225	2468	19.56

TABLE 5 (Contd.)

No. of tests avgd.	Time		Fall Distance		Maximum Riser Forces [c]			Rate of descent MSL
	Container open to full open [a] (sec)	Container open to equilibrium [b] (sec)	Container open to full open (ft)	Container open to equilibrium [b] (ft)	Right (lb)	Left (lb)	Total (lb)	(ft/sec)
B-66 Aircraft @ 150 KIAS -- 10,000 ft. altitude								
4	1.95	4.75	98.6	182.4	1313	1243	2500	16.82
B-66 Aircraft @ 150 KIAS -- 15,000 ft. altitude								
4 [d]	1.94	3.60	513.4	575.1	1762	1643	2250	NA
B-66 Aircraft @ 175 KIAS -- 5,000 ft. altitude								
4	1.88	4.87	79.1	157	1637	1431	3056	18.98
B-66 Aircraft @ 175 KIAS -- 10,000 ft. altitude								
4	1.62	5.9 (3 tests)	71.5	179 (3 tests)	1941 (3 tests)	2416 (3 tests)	3391 (3 tests)	19.02 [e] (2 tests)
B-66 Aircraft @ 175 KIAS -- 15,000 ft. altitude								
4	1.55	4.4	72.5	148	2093	2206	3847 (3 tests)	18.00 (2 tests)
B-66 Aircraft @ 200 KIAS -- 5,000 ft. altitude								
4	1.95	4	86.8	141	1606 (3 tests)	1683 (3 tests)	3250 (3 tests)	20.01
B-66 Aircraft @ 200 KIAS -- 10,000 ft. altitude								
3	1.82	8.9	77	211	1733	1806	3466	19.73

TABLE 5 (Contd.)

No. of tests avgd.	Time		Fall Distance		Maximum Riser Forces [c]			Rate of descent MSL
	Container open to full open [a] (sec)	Container open to equilibrium [b] (sec)	Container open to full open (ft)	Container open to equilibrium [b] (ft)	Right (lb)	Left (lb)	Total (lb)	(ft/sec)
B-66 Aircraft @ 200 KIAS -- 15,000 ft. altitude								
4	1.69	6.45	77.4	199	2193	2056	4181	19.16 (1 test)
B-66 Aircraft @ 225 KIAS -- 5,000 ft. altitude								
4	1.83	4.37	81.3	168	1946	1865	3768	17.71 (3 tests)
B-66 Aircraft @ 225 KIAS -- 10,000 ft. altitude								
4	1.81	4.45	73.1	147	1[illegible]68	2281	4257	18.04

[a] Average time from container opening until parachute reaches full open:

Deployment sleeve	2.19 seconds
Deployment bag	1.80 seconds

[b] Time at which the first minimum rate of descent is attained after parachute reaches full open.

[c] The riser forces are the maximum recorded but not necessarily at the same instant. The total force is the maximum instantaneous sum of the riser forces.

[d] During these tests the dummies were permitted to fall 5,000 feet prior to actuation of the parachute.

[e] One canopy incurred major damage.

TABLE 6. Results of Live Jump Tests with Jumper at Terminal Velocity - Minimum Safe Deployment Altitude

Drop No.	Gross weight of parachutist (lbs)	Time			Fall Distance
		Ripcord pull to container open (sec)	Container open to full open (sec)	Interval between ripcord pull and full open[a] (sec)	Ripcord pull to full open[b] (ft)
C-47 Aircraft @ 110 KIAS -- 7,000 ft. pressure altitude					
2177N	216	.065	3.63	3.695	513
2178N	216	.148	3.022	3.170	497
2179N	197	.063	3.872	3.935	533
2180N	227	.101	3.367	3.468	503
2181N	205	.10	3.3	3.4	460
2187N	208	.065	3.502	3.567	544
2188N	216	.044	3.435	3.479	468
2189N	215	.065	3.333	3.398	490
2190N	195	.085	2.95	3.035	410
2191N	216	.099	4.574	4.673	635
2192N	210	.098	3.078	3.176	428
2193N	205	.099	3.801	3.9	491
2194N	204	.022	2.968	2.99	433
2195N	200	.045	2.868	2.913	458
2196N	195	.023	3.402	3.425	318

TABLE 6 (Contd.)

Drop No.	Gross weight of parachutist (lbs)	Time: Ripcord pull to container open (sec)	Time: Container open to full open (sec)	Time: Interval between ripcord pull and full open[a] (sec)	Fall Distance: Ripcord pull to full open[b] (ft)
U1B Aircraft @ 100 KIAS -- 7,000 ft. pressure altitude					
2182N	213	.06	3.733	3.793	464
2183N	200	.115	3.399	3.514	449
2184N	197	.10	3.865	3.965	480
2185N	208	.07	3.318	3.388	443
2186N	234	.07	2.80	2.87	428

[a] Average time between ripcord pull and full open parachute was 3.48 seconds.

[b] Average fall distance from ripcord pull to full open parachute was 472.25 feet.

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DIAMETER EXTENDED SKIRT MANEUVERABLE
PERSONNEL PARACHUTE CANOPY ASSEMBLY
WITH "TU" ORIFICE, by George L. C.
Menard. April 1967. 40 p. 11 figs.
UNCLASSIFIED

This report describes the test and evaluation of a maneuverable personnel parachute canopy assembly modification. A "TU" orifice was installed in the canopy, and control lines

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Personnel
Parachute
I. Menard, G. L. C.

Task: AIRTASK
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13. ABSTRACT

This report covers the development, test, and evaluation of a maneuverable personnel parachute canopy assembly modification. The canopy assembly tested was constructed from the basic 35-foot diameter extended skirt canopy assembly, AF 49J7141-2, used with Personnel Parachute, Troop-Back, 35-Foot Diameter, Type T-10, A/P28S-14. A "TU" type of orifice was installed in the canopy, and the slip risers utilized with the maneuverable personnel parachute assemblies, A/P28S-10 (Static Line) and A/P28S-13 (Free Fall) for steering the parachute, were replaced by risers, AF 59C6174, and control lines.

The results of this test and evaluation program indicate the canopy assembly modification provides more maneuverability and a better turn rate performance than that currently obtainable with the maneuverable personnel parachute assemblies, types A/P28S-10 and A/P28S-13.

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